

Nutrient modeling highlights from the Puget Sound region

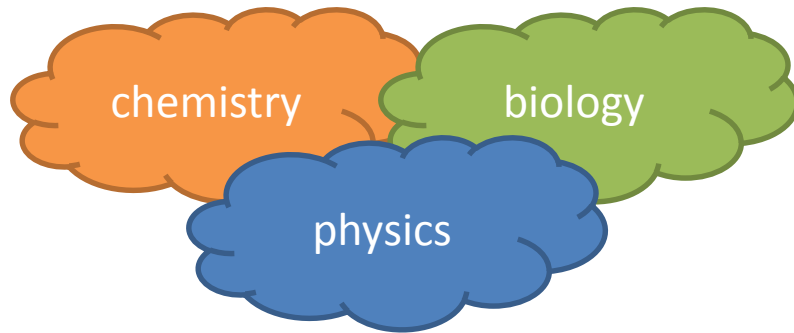


Mindy Roberts
Anise Ahmed
Greg Pelletier
Teizeen Mohamedali
(Dept of Ecology)

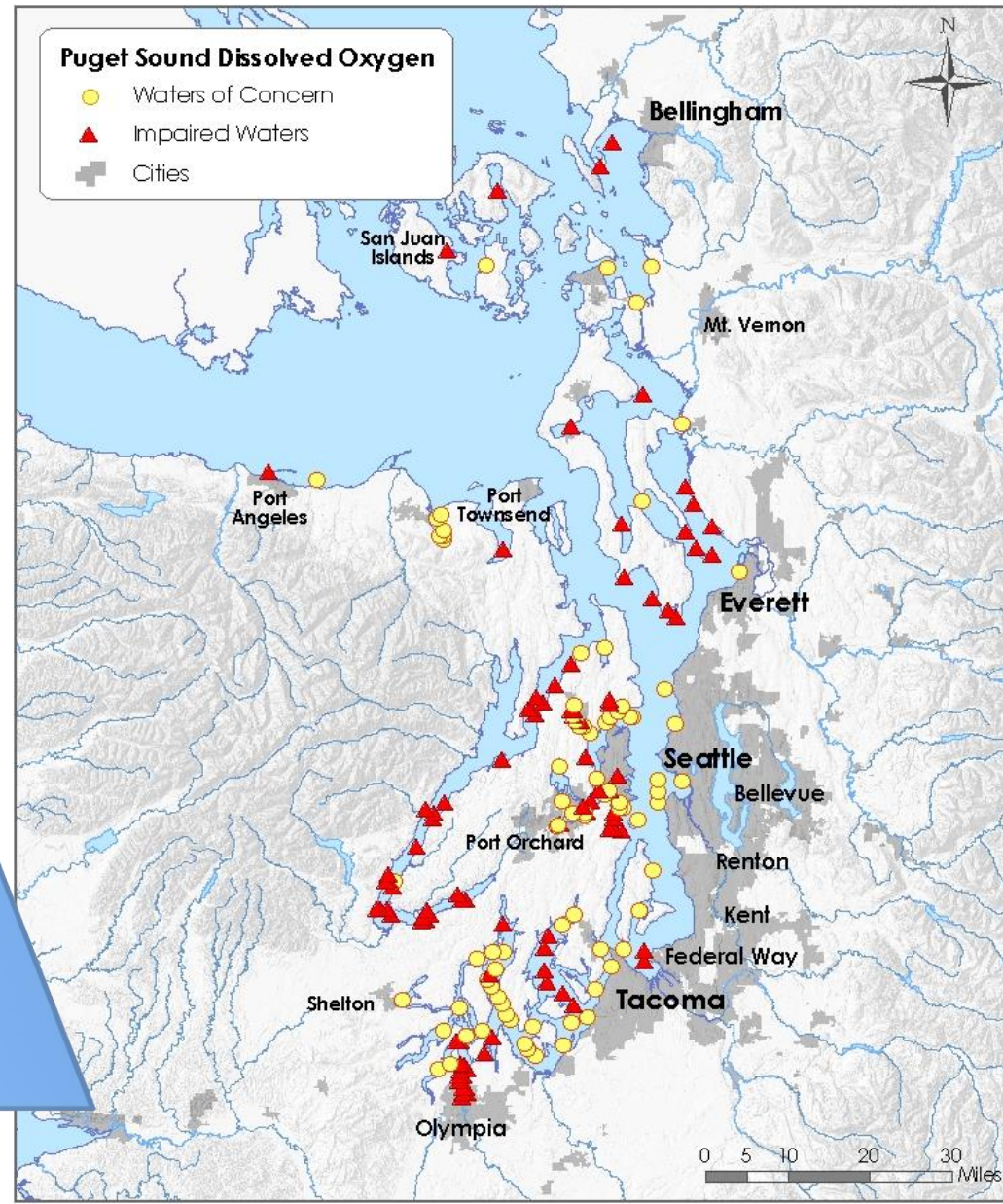
Tarang Khangaonkar
Wen Long
(PNNL)



Oxygen biologically relevant, many factors...



Pacific Ocean dissolved oxygen levels, coastal upwelling, Pacific Decadal Oscillation, other climate cycles, NE Pacific oxygen trends, ocean circulation, residence time, estuarine circulation, stratification, vertical mixing, wind, air temperature, organic matter decay, sediment burial rates, trophic-level dynamics, algae growth, water temperature, human wastewater input, river flows, river nutrient inputs, sediment-water processes, etc. ...

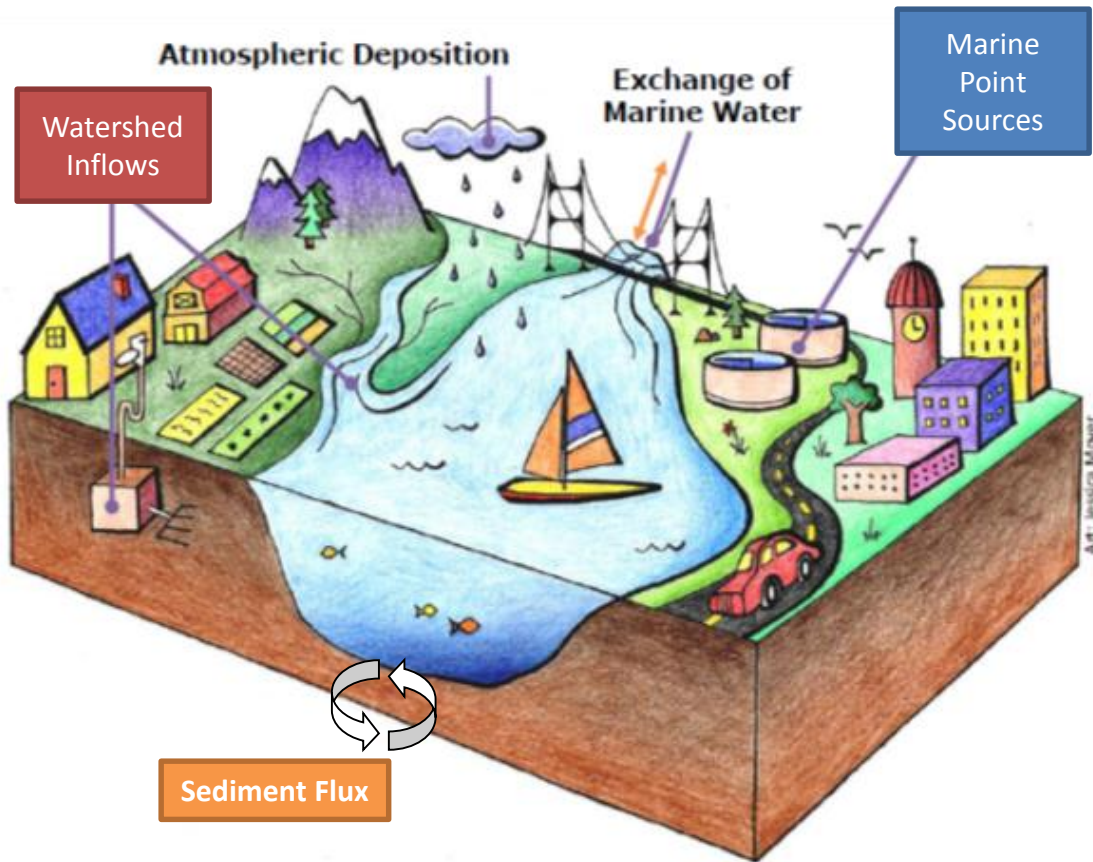


What are the key regulatory questions?

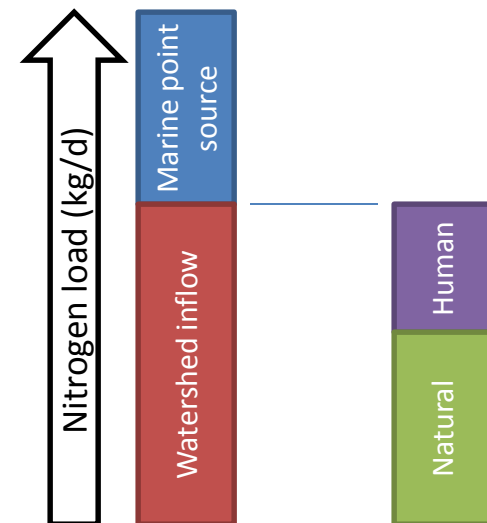
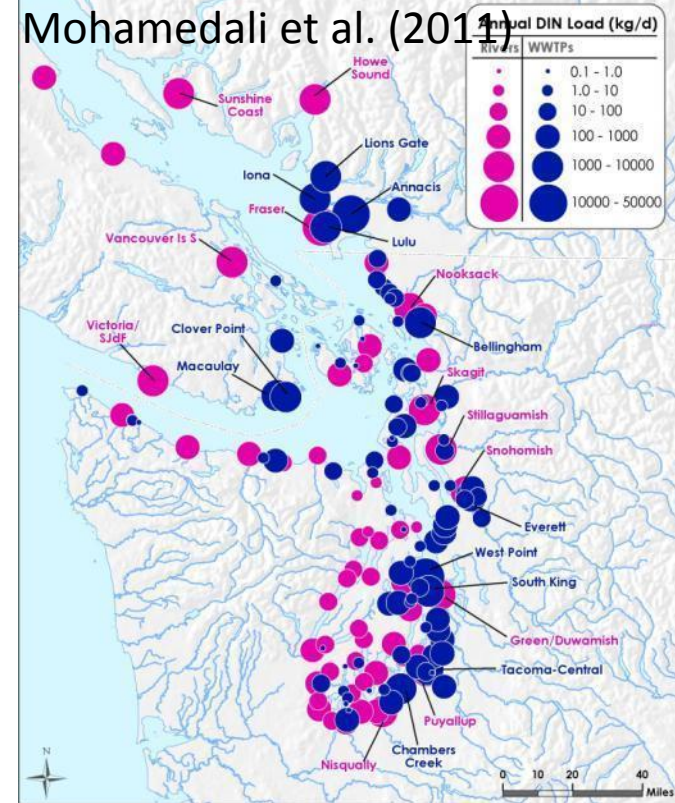
(freshwater and marine water)

- How much of the low oxygen is due to natural conditions and how much is human?
 - *Need sophisticated computer models to distinguish human from natural/climate influences*
- How much human impact reduction is needed to meet water quality standards (<0.2 mg/L below natural conditions)?
- Are NPDES permit changes needed to meet water-quality based effluent limits?
- *We don't know yet...*

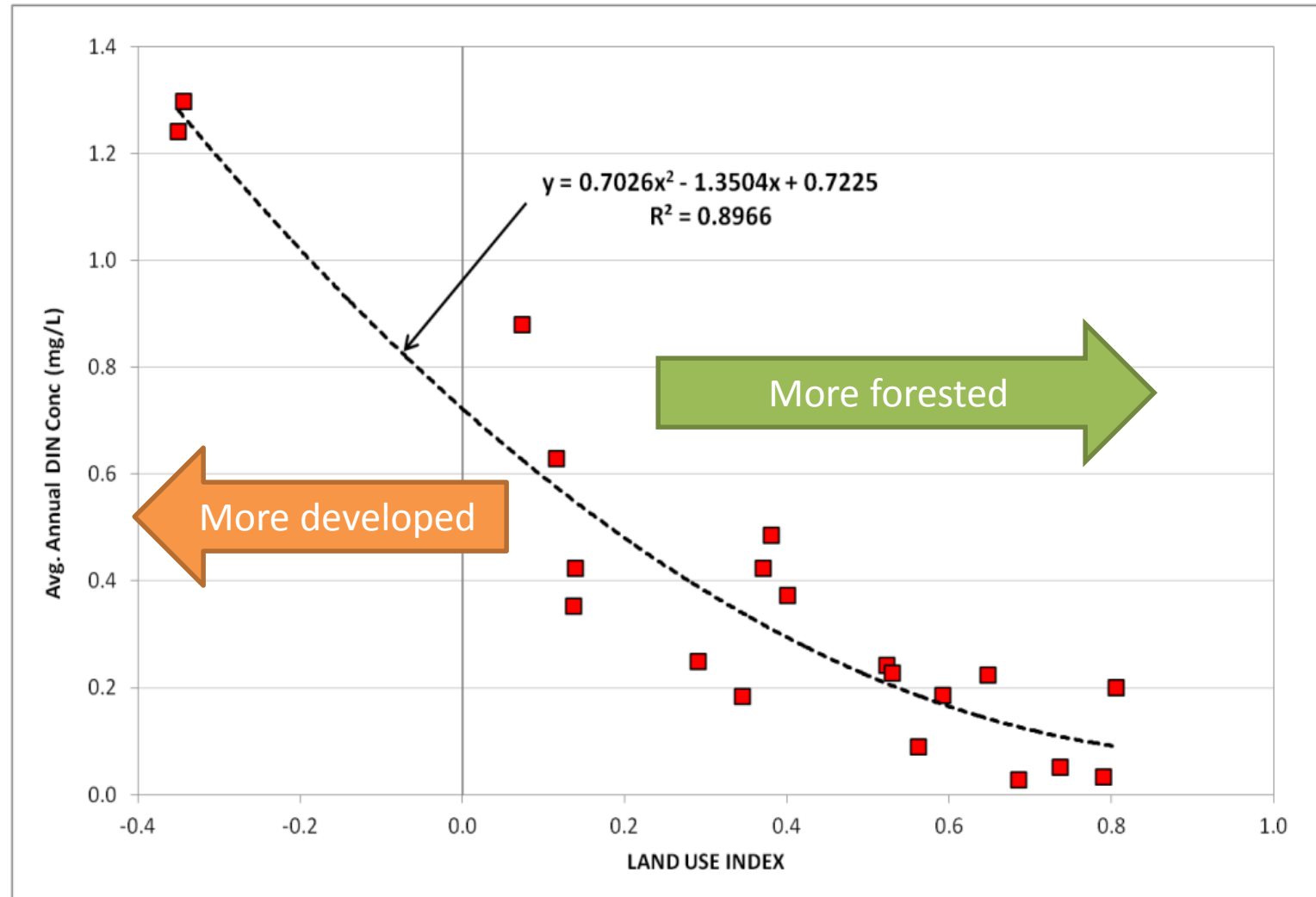
What are the sources of nitrogen?



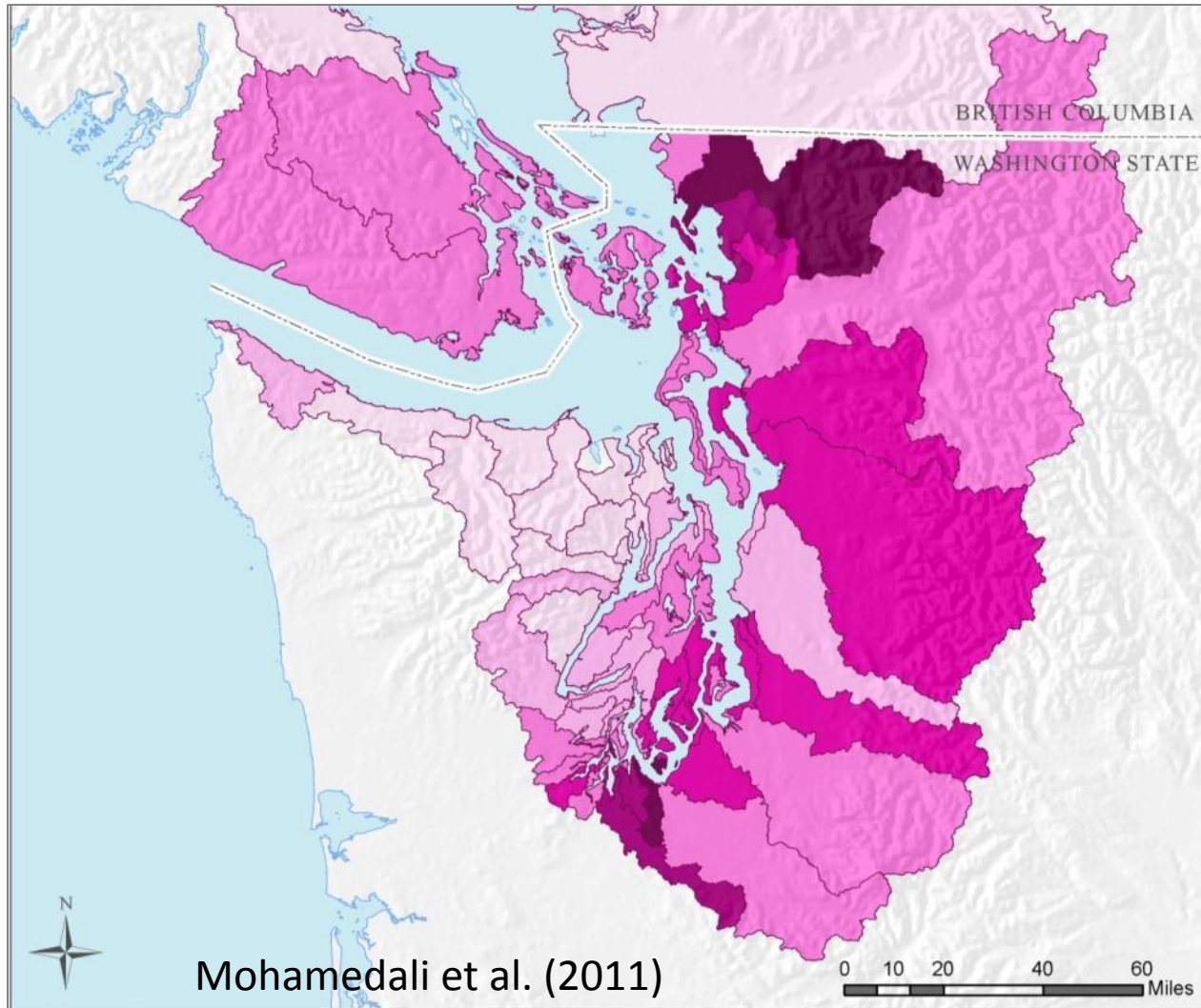
Dissolved inorganic nitrogen (DIN) = nitrate + nitrite + ammonium



River nutrient concentrations reflect watershed land use

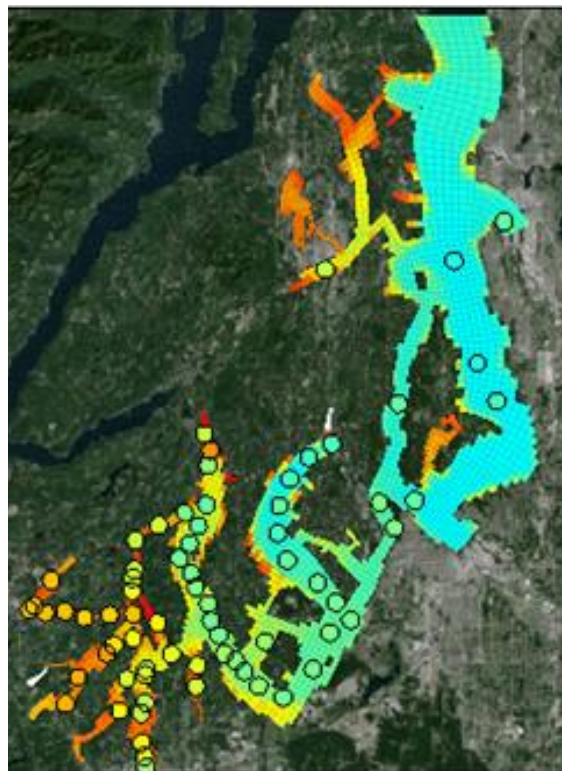


River unit-area nitrogen loads reflect watershed land use and precipitation



Example spatial patterns – April 2007

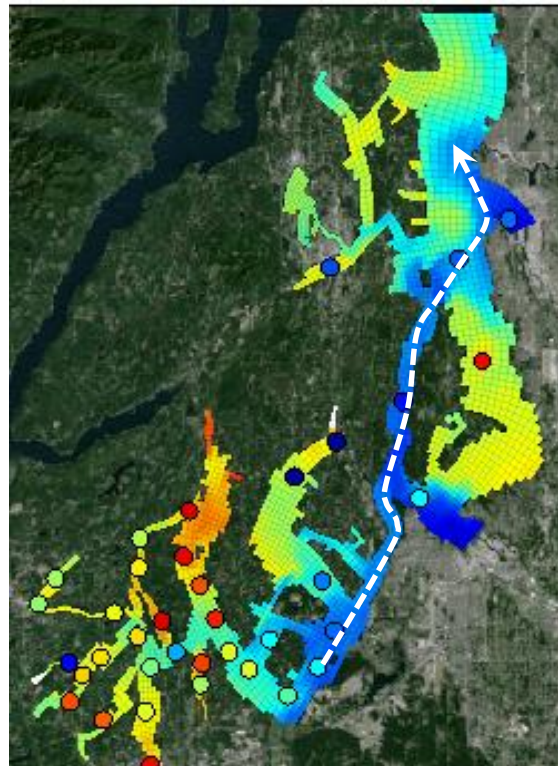
Bottom Dissolved
Oxygen



Conc. of DO mg/l

0 3 6 9 12 15 18

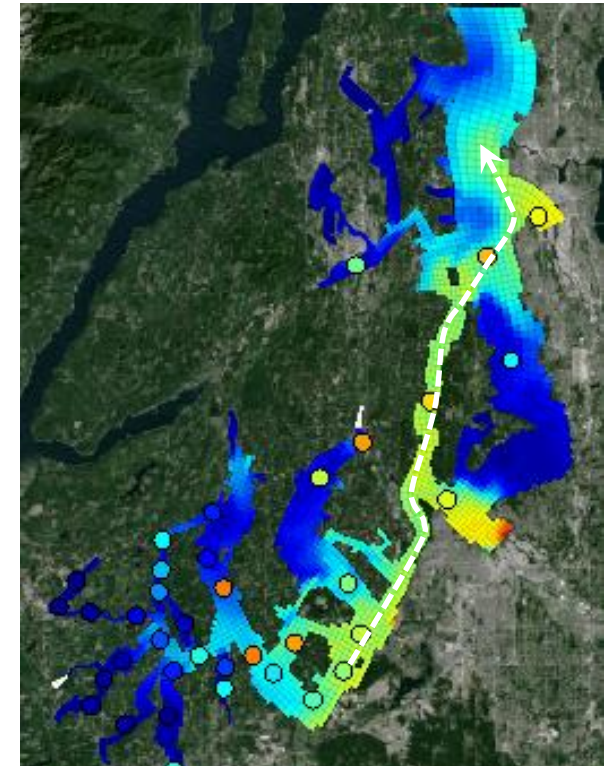
Surface Chlorophyll



Tot. Chlorophyll $\mu\text{g/L}$

0 8.33 16.67 25 33.33 41.67 50

Surface Dissolved
Inorganic Nitrogen

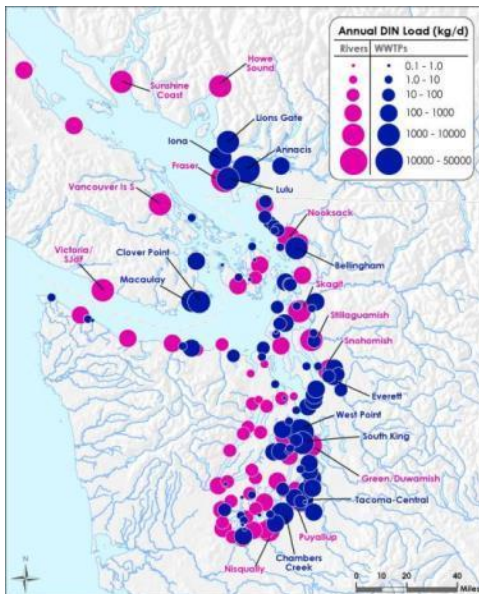


DIN mg/L

0 0.08 0.17 0.25 0.33 0.42 0.5

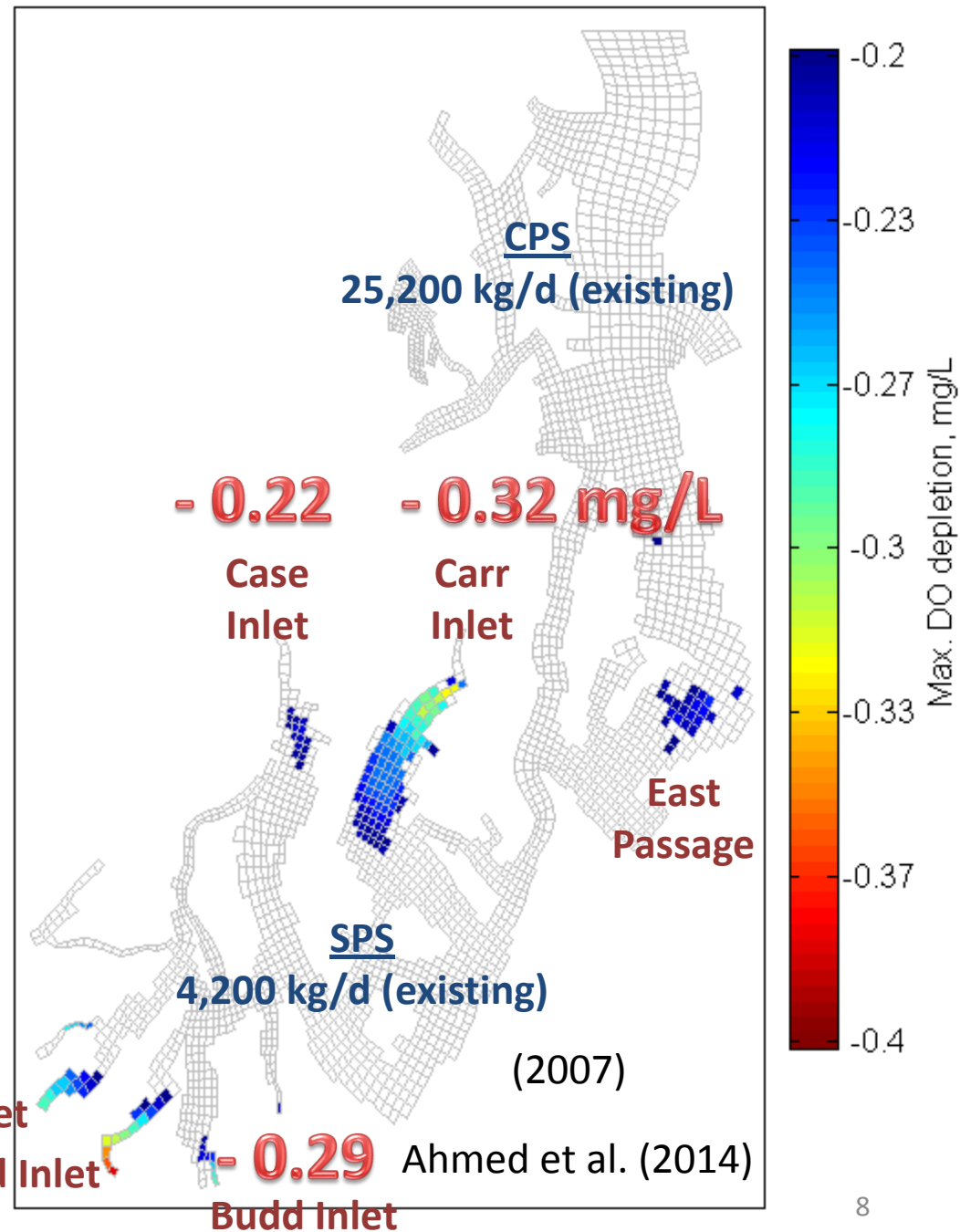
Human DO impacts below natural conditions

(wastewater plants +
human inputs to rivers)

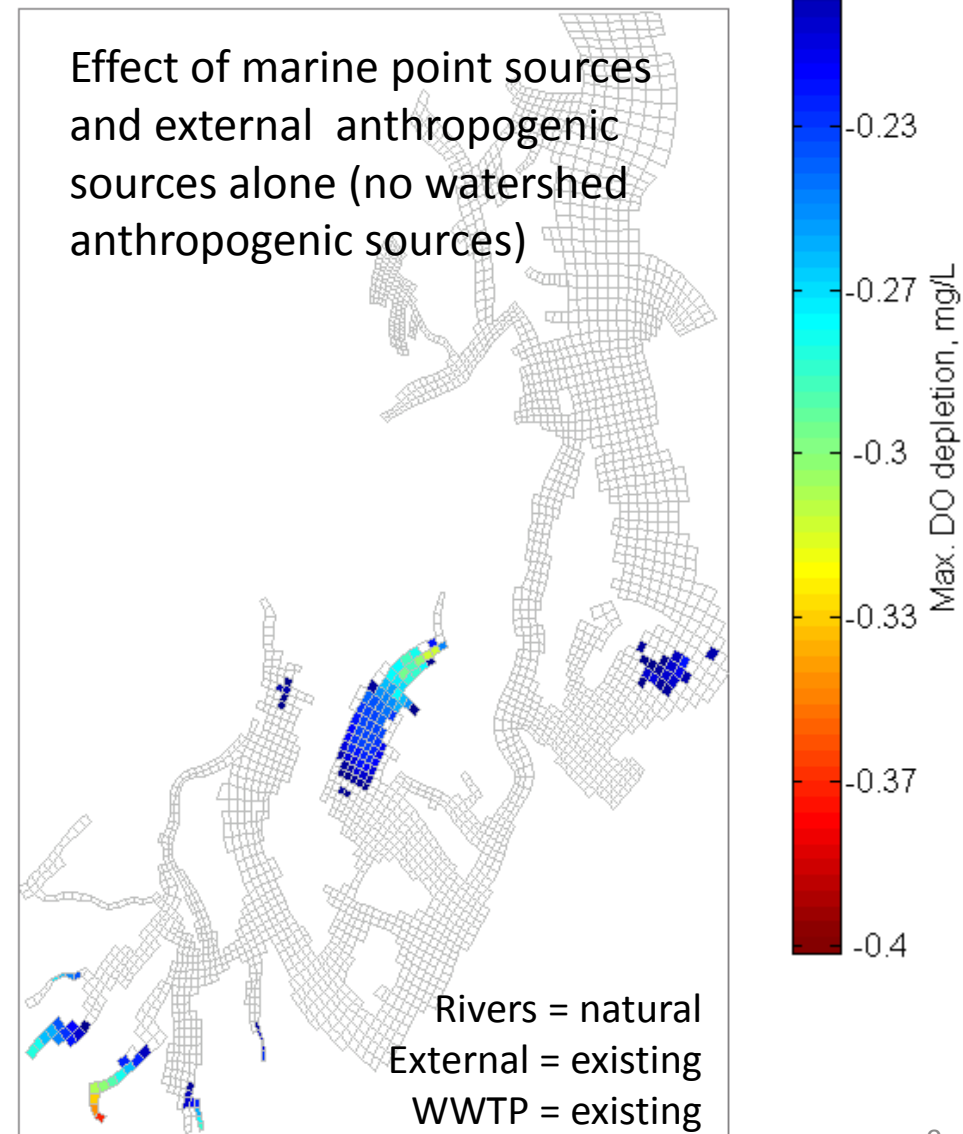
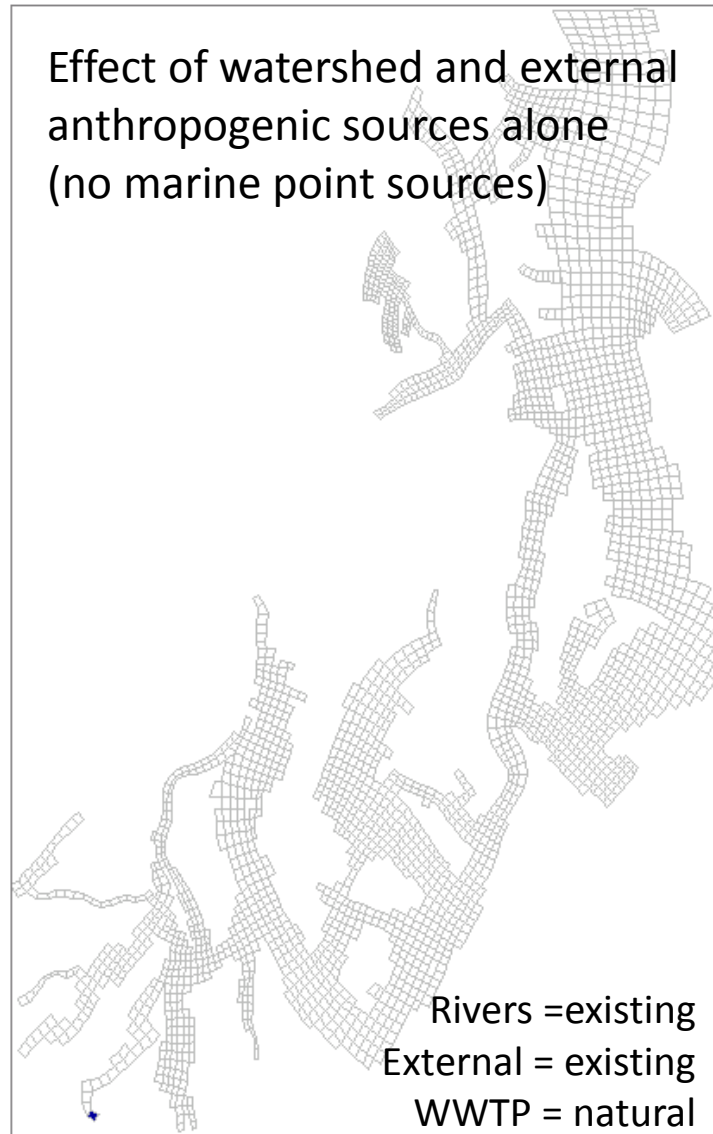


- 0.29 Totten Inlet

- 0.38 Eld Inlet



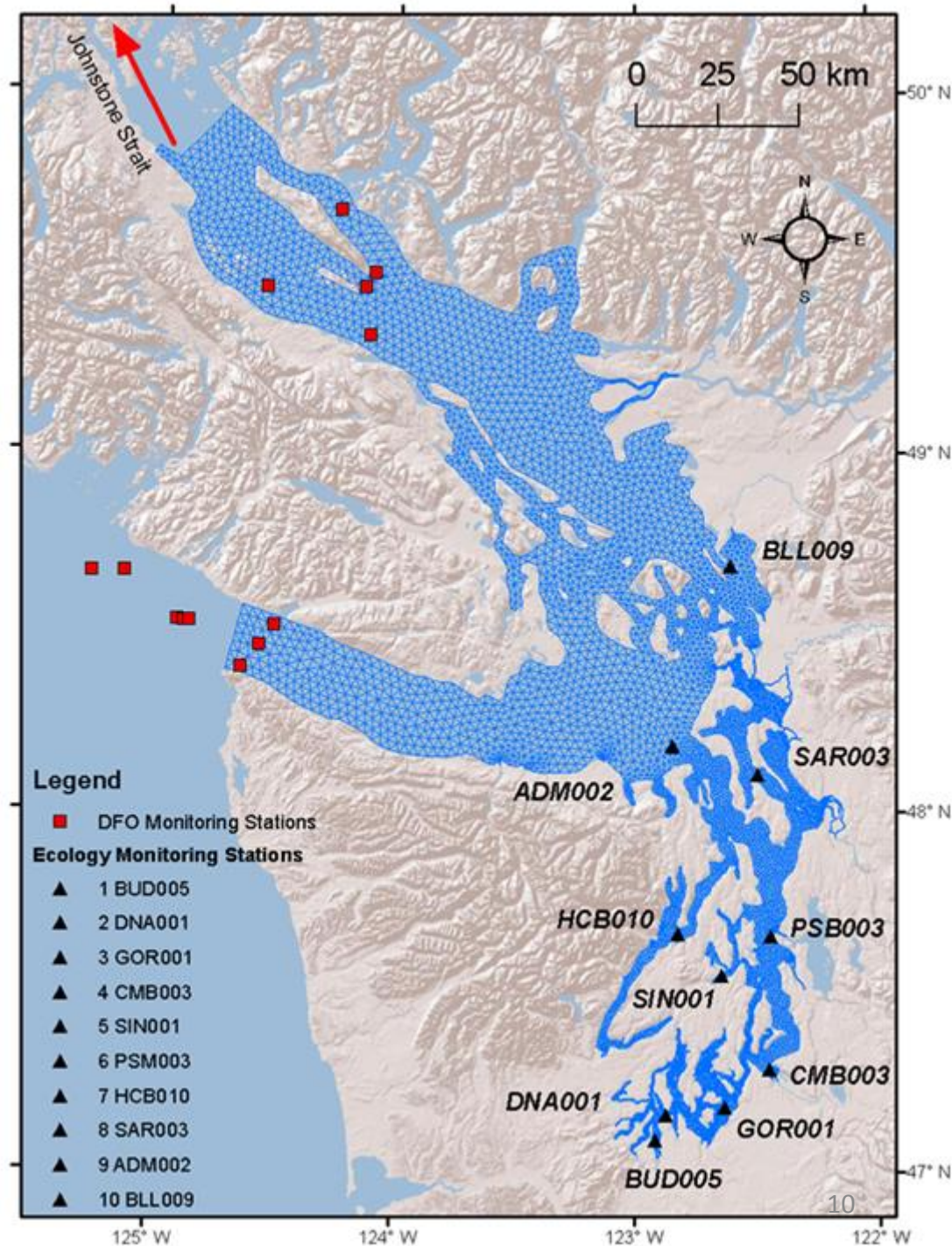
Marine point sources have greater influence than watershed sources



Salish Sea model

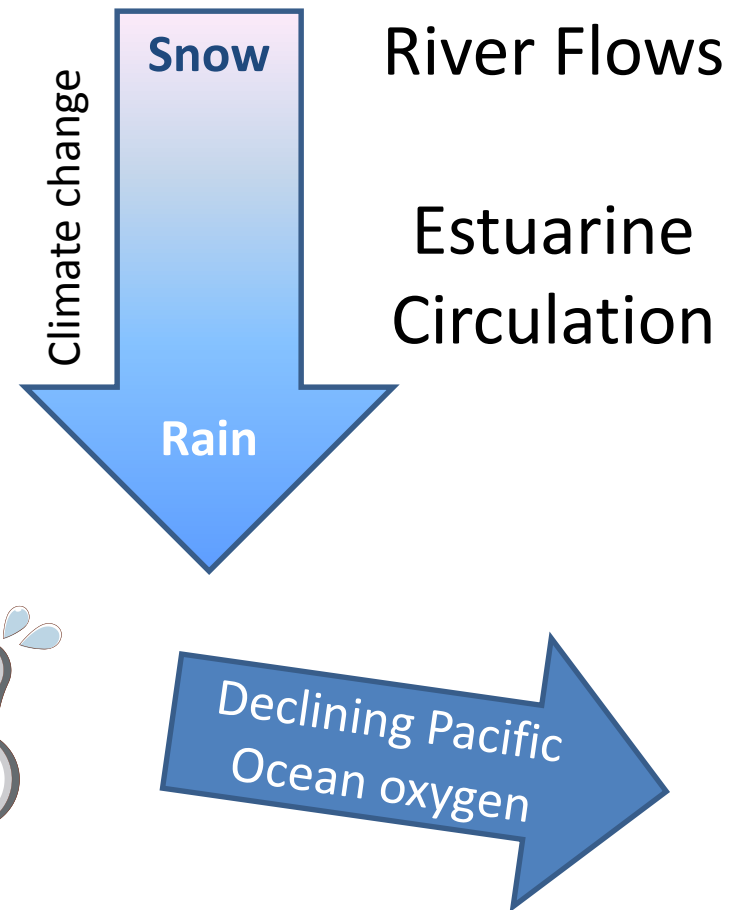
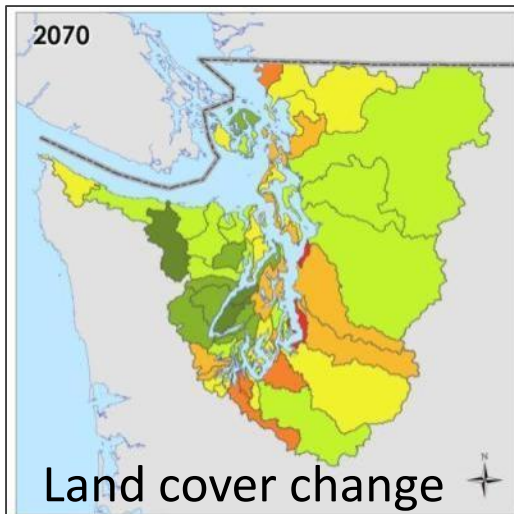
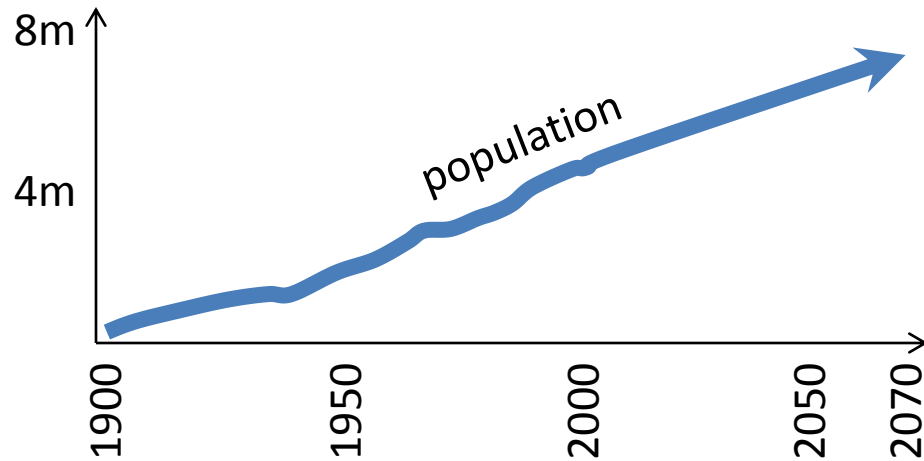
- 3D calibrated model of the Salish Sea
- Predicts circulation and water quality

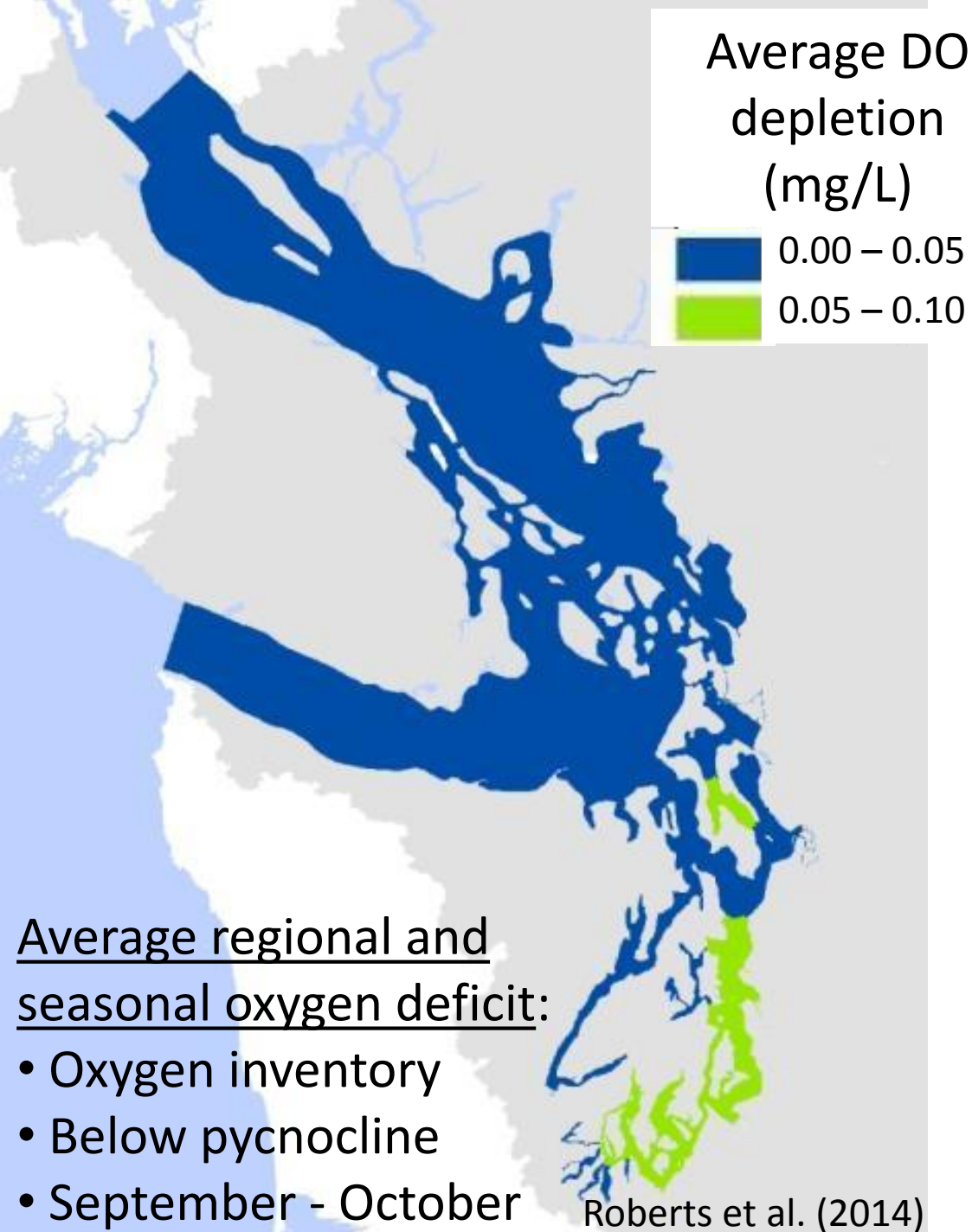
Khangaonkar et al. (2012)



Current and Future Scenarios

(now, 2020s, 2040s, 2070s)



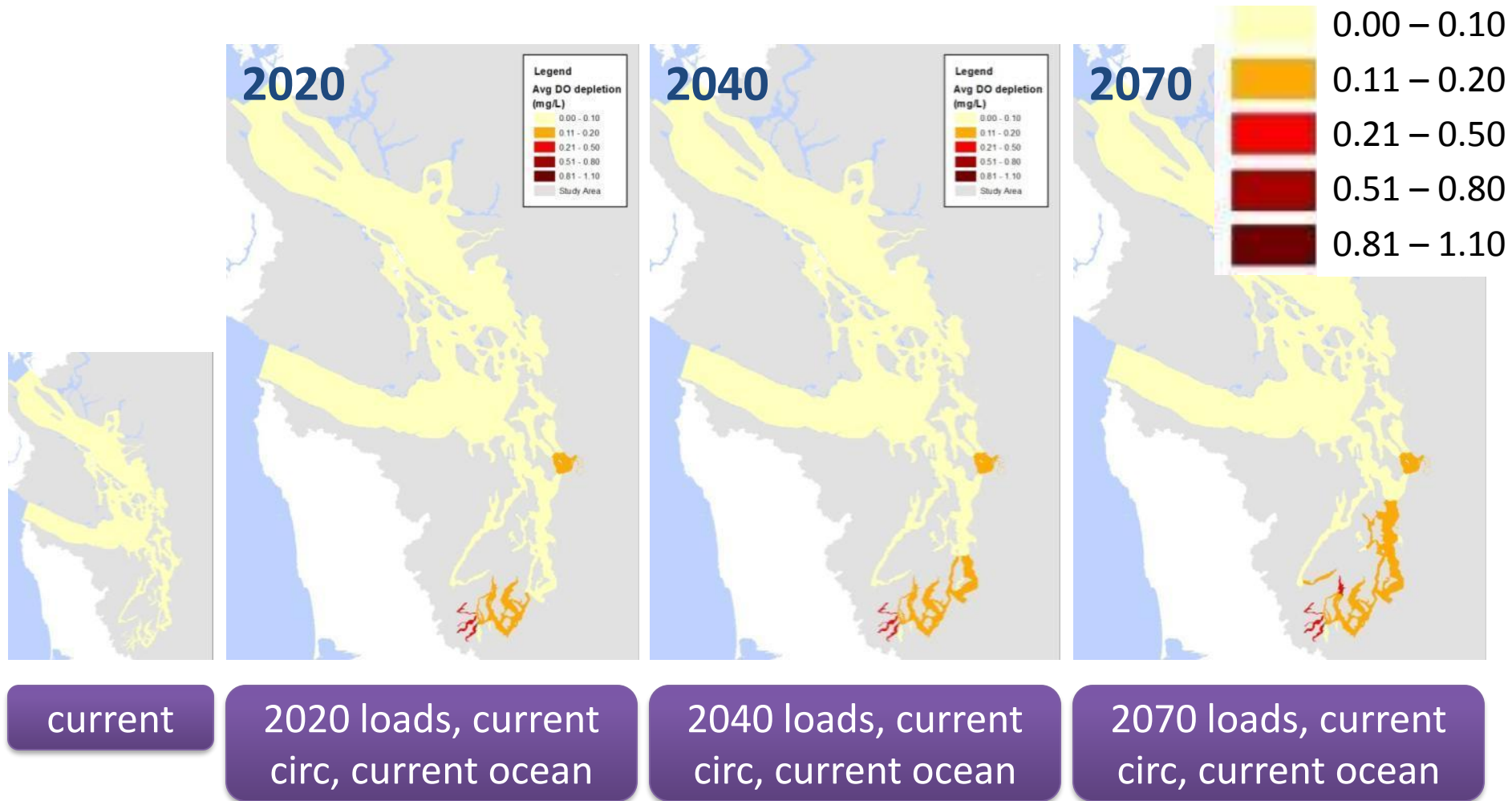


Oxygen depletion – current sources (wastewater, watersheds)

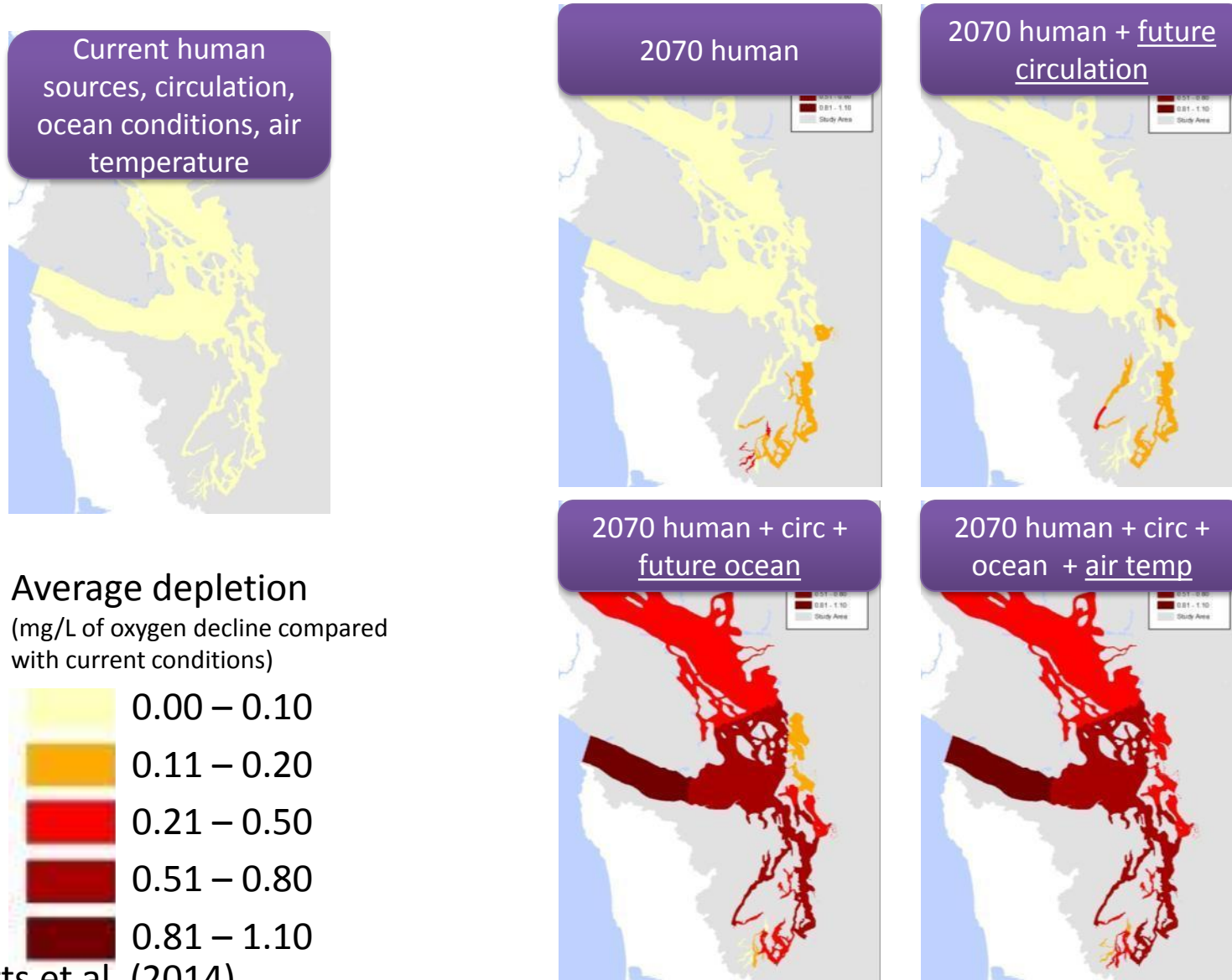
- *Biggest impacts in South and Central Puget Sound*
- *Not directly applicable to State of WA water quality standards*

Oxygen depletion – future marine point sources and watershed inflows

Average DO depletion
(mg/L)



Future population growth will increase oxygen impacts; ocean trends would make it worse



Freshwater example – Deschutes River



How to improve river oxygen (and pH)

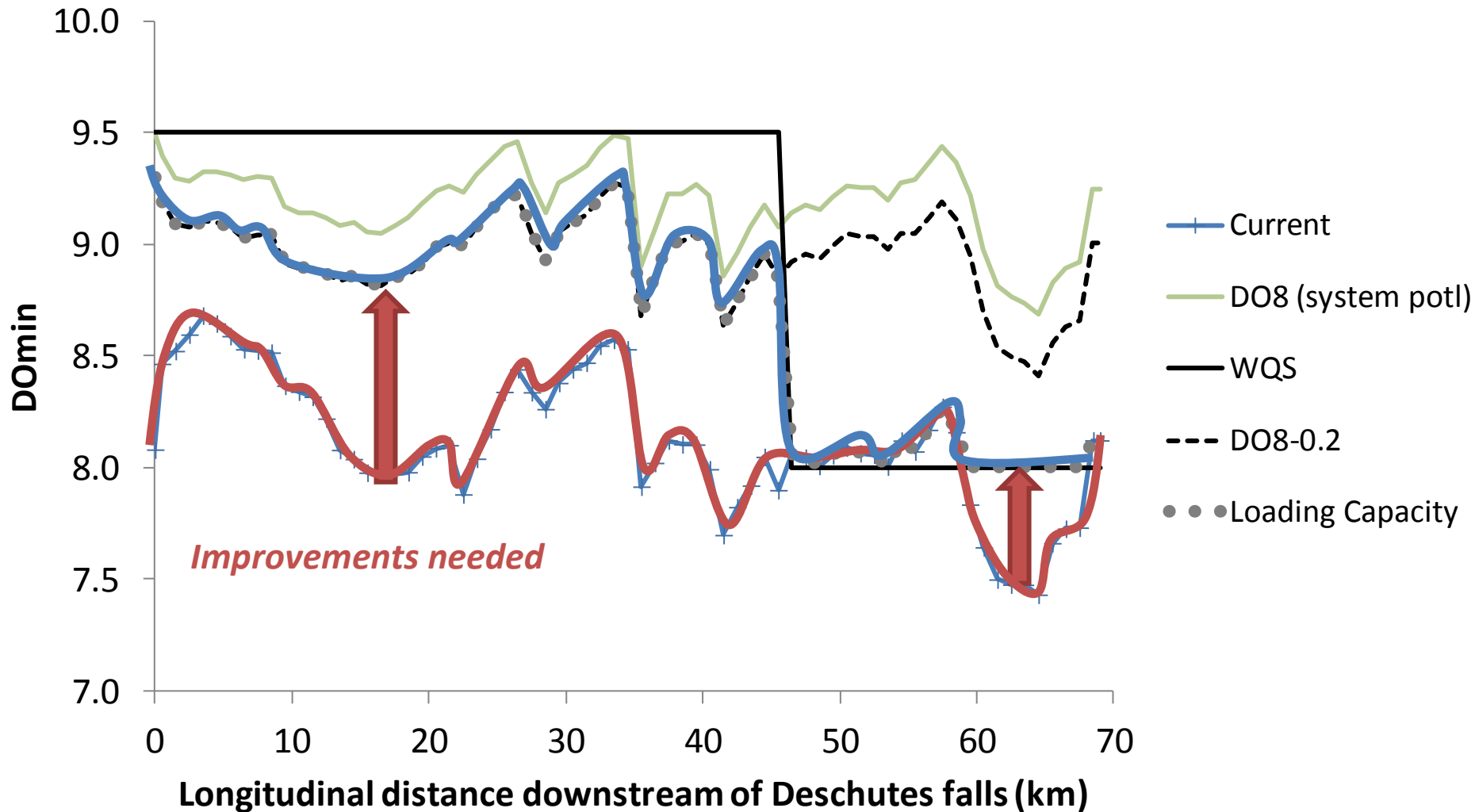
Shade, microclimate,
floodplain, nutrient uptake,
high channel complexity, low
nutrient inputs, etc.



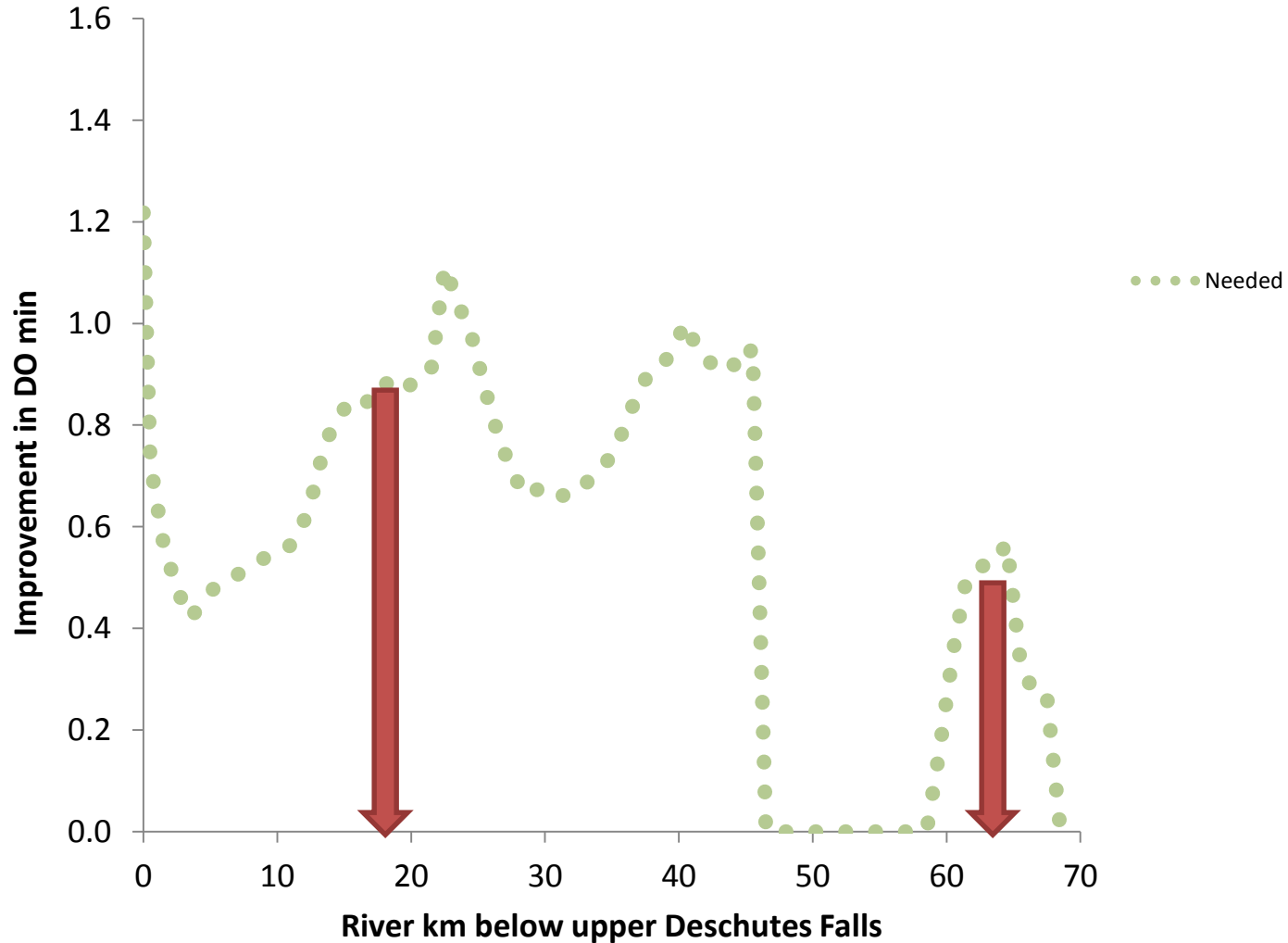
No shade, no microclimate, no
floodplain, low nutrient uptake,
low channel complexity, high
nutrient inputs, etc.



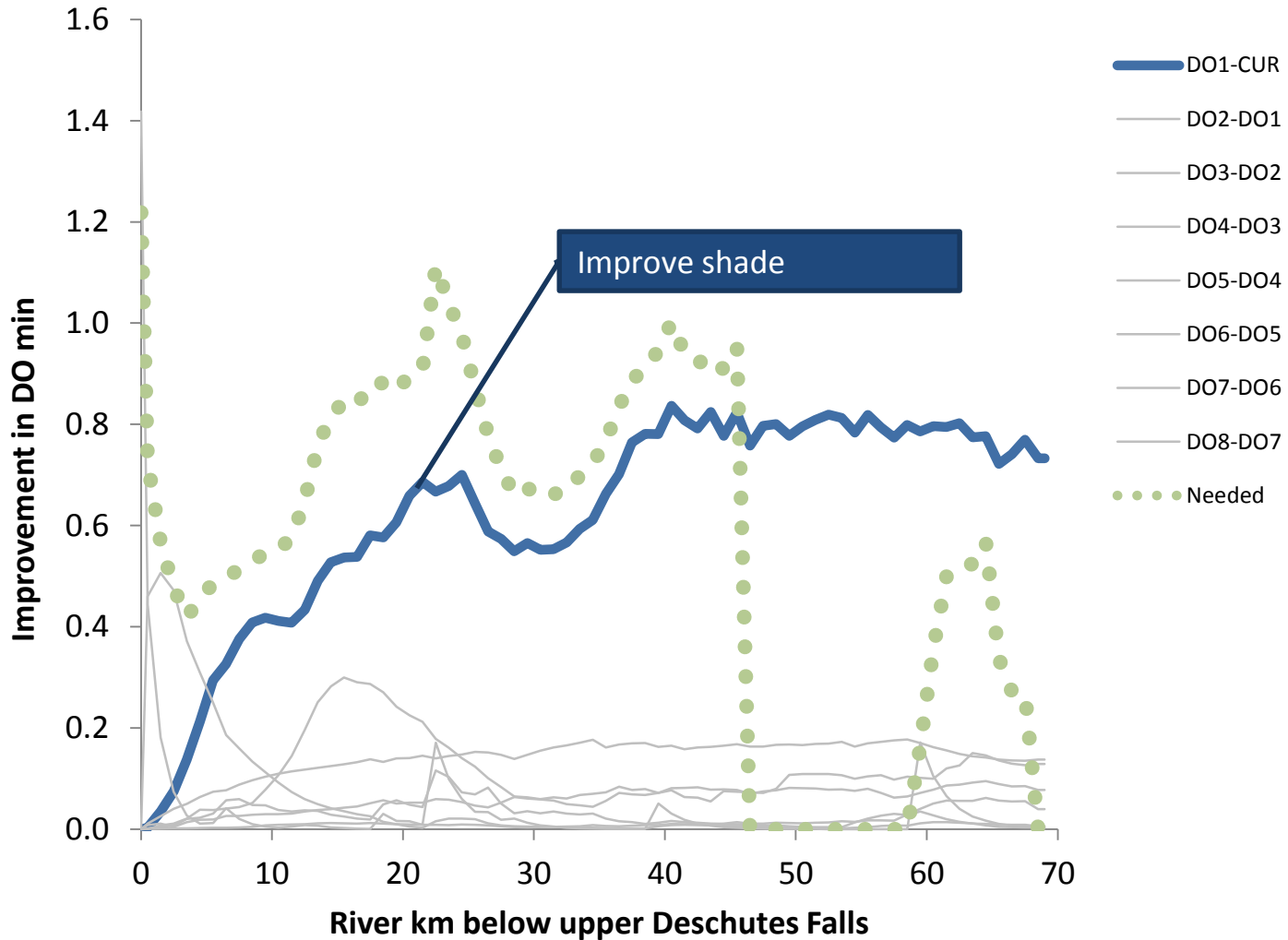
Daily minimum dissolved oxygen under current and system potential conditions plus loading capacity



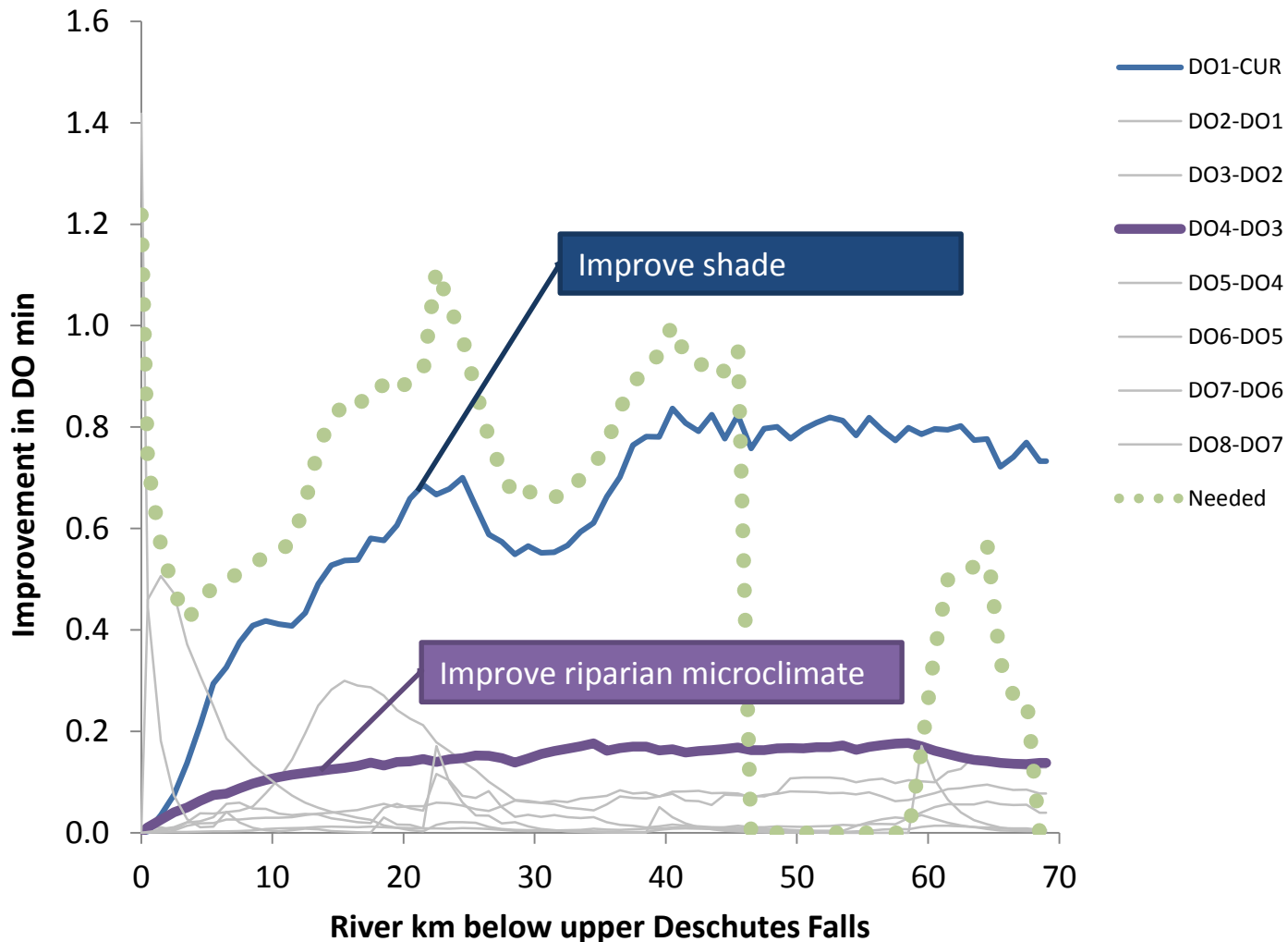
Needed improvements in minimum oxygen



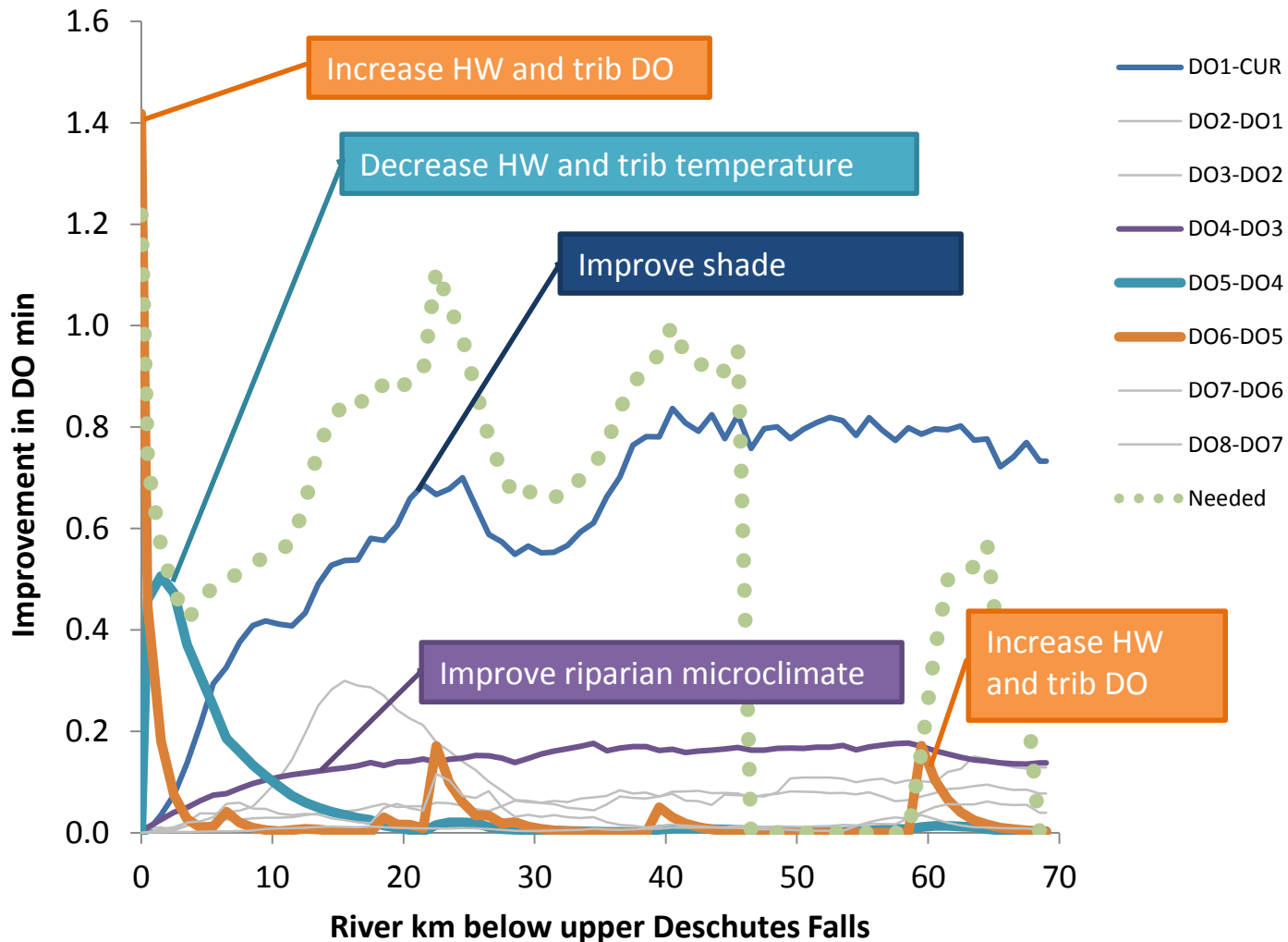
Minimum oxygen improvements by management practice



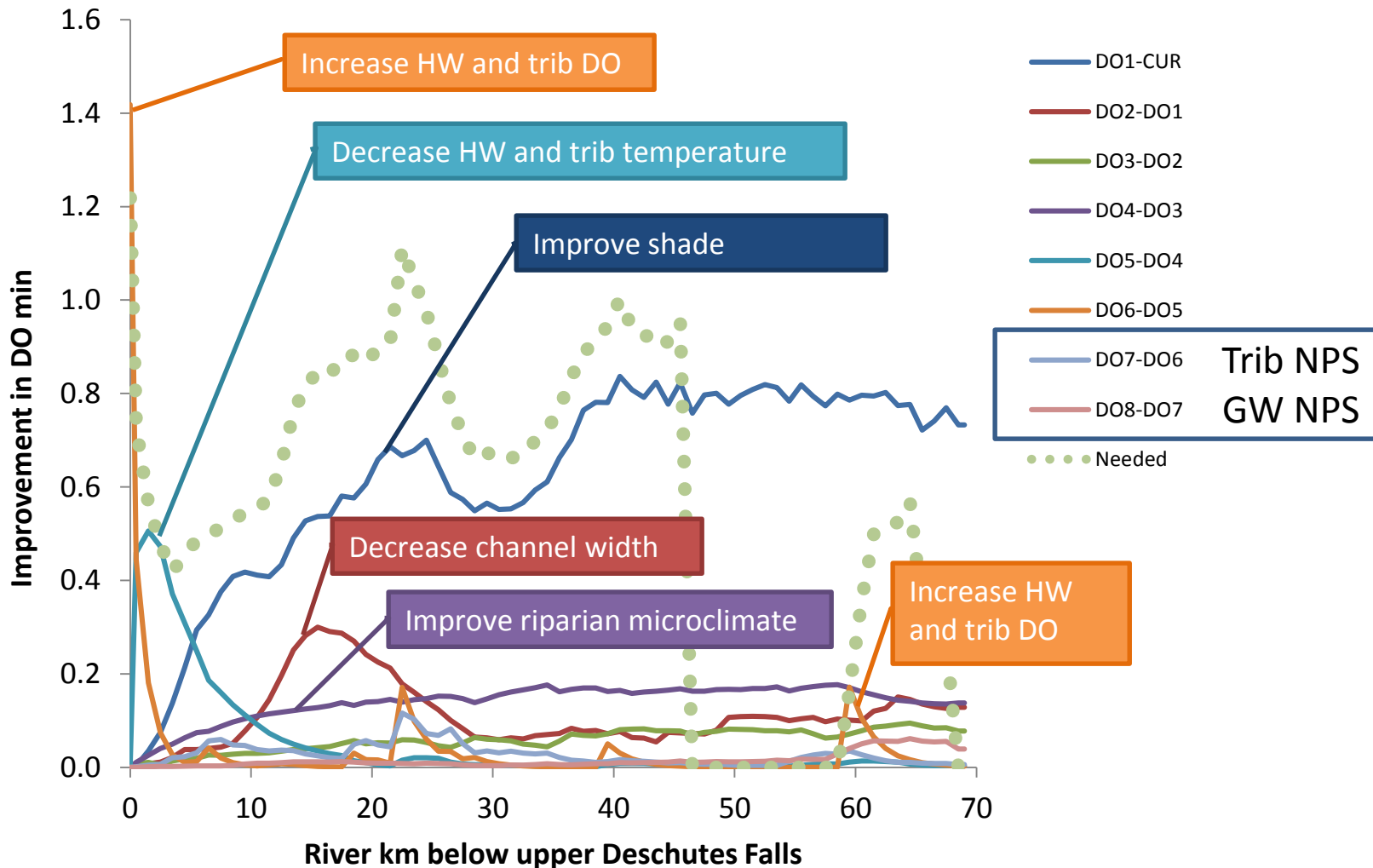
Minimum oxygen improvements by management practice



Minimum oxygen improvements by management practice



Minimum oxygen improvements by management practice



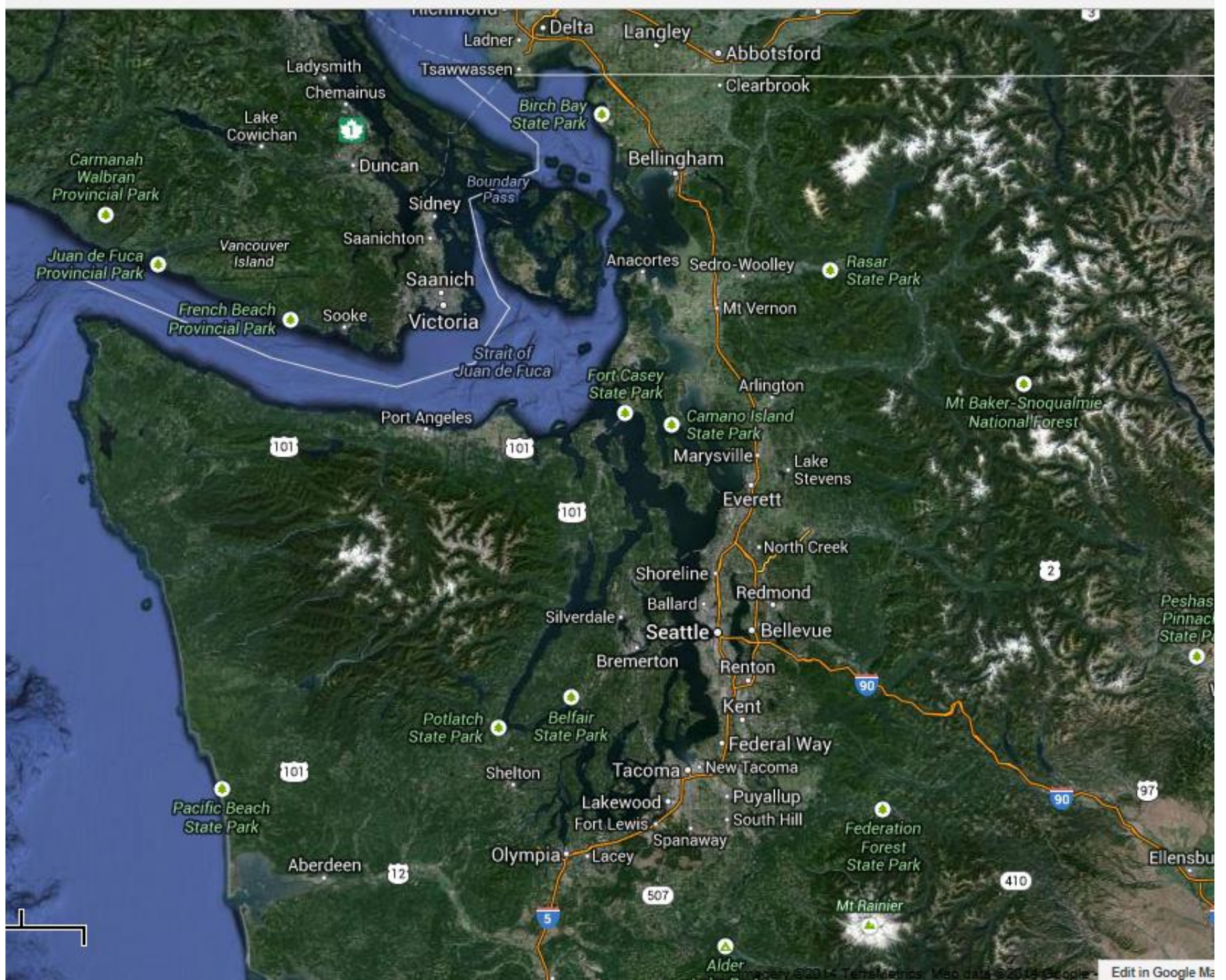
Deschutes River scenario results

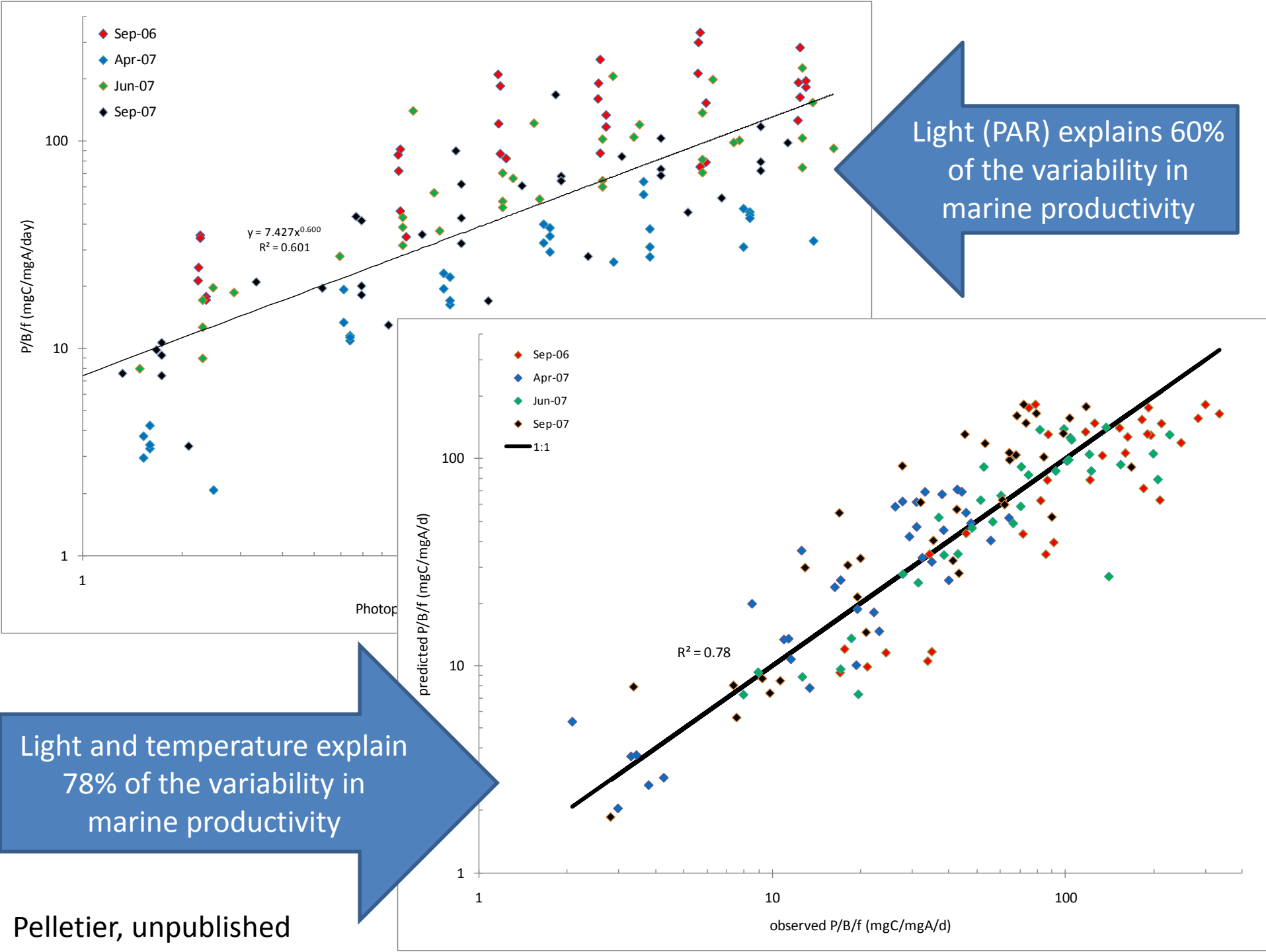
- NPS reductions alone will not meet water quality standards
- Restoring mature riparian vegetation and channel structure would have the greatest benefit to DO and

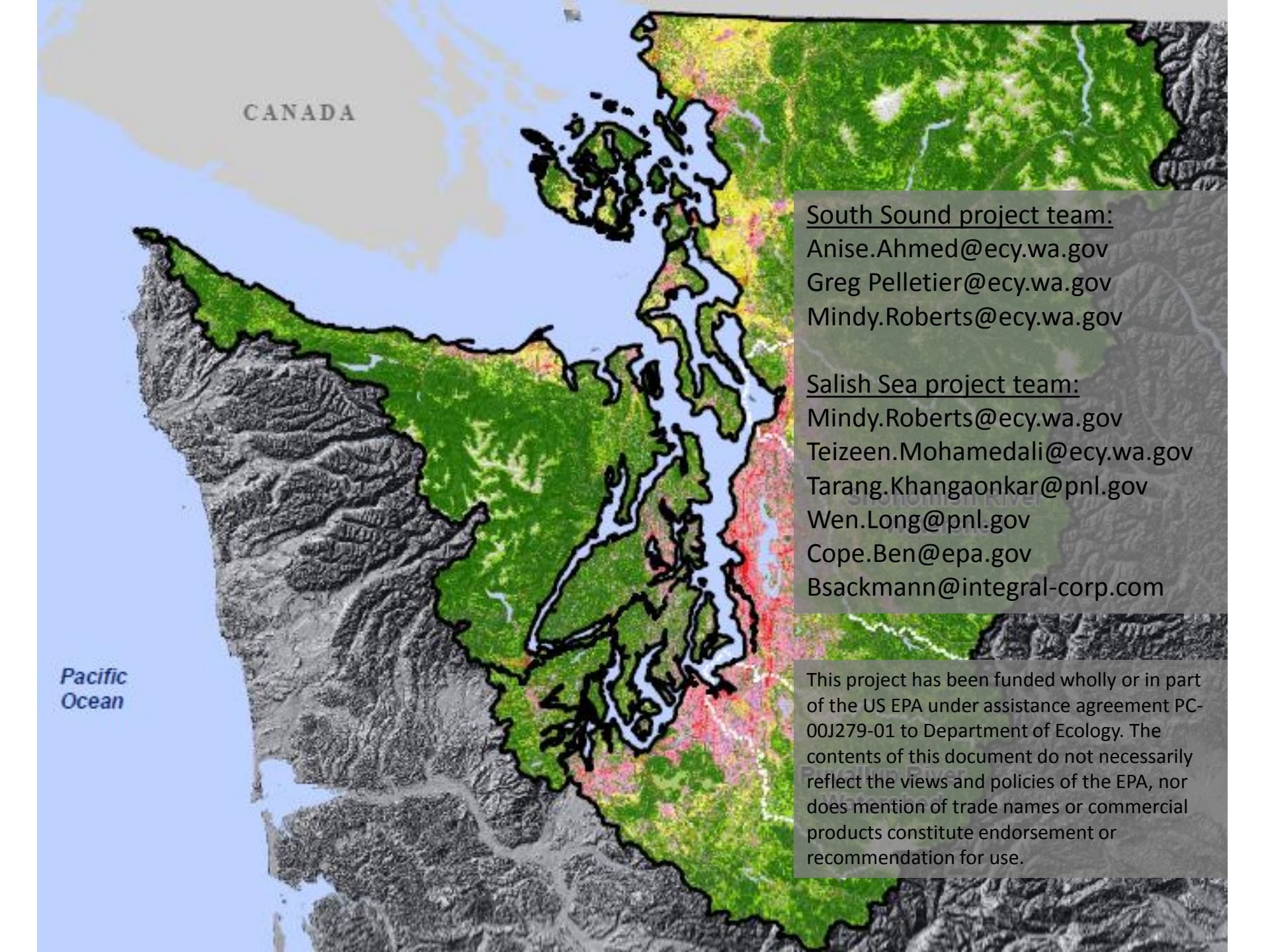


Next steps for marine nutrient modeling

- Publish South Sound and Salish Sea reports February 2014
- Update Salish Sea model with linked sediment-water exchanges (diagenesis)
 - Funded through 2015
 - Draft model approach document
- Use updated Salish Sea model to refine South Sound predictions of local source impacts





A topographic map of Washington state, showing elevation with green for lower elevations and brown/grey for higher elevations. The map includes the Pacific Ocean to the west, Canada to the north, and the Salish Sea to the east. The state's coastline is clearly defined, and major river networks are visible.

CANADA

Pacific
Ocean

South Sound project team:

Anise.Ahmed@ecy.wa.gov

Greg Pelletier@ecy.wa.gov

Mindy.Roberts@ecy.wa.gov

Salish Sea project team:

Mindy.Roberts@ecy.wa.gov

Teizeen.Mohamedali@ecy.wa.gov

Tarang.Khangaonkar@pnl.gov

Wen.Long@pnl.gov

Cope.Ben@epa.gov

Bsackmann@integral-corp.com

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References

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